UCN-2383
(3 11-60)

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DATE: March 20, 1962

COPY NO. 25

SUBJECT: Calculations of Permissible Release of Radioiodine to Hood Exhaust

TO: Listed Distribution

FROM: W. E. Browning, Jr.

Abstract

An analysis was made of the consequences of releasing radioiodine through the hood exhaust in certain laboratories in Bldg. 4500S. The controlling exposure is that of a person breathing undiluted hood exhaust on the roof of the building. It was concluded that 0.25 mc of I^{131} could be released without exceeding permissible exposures. The installation of charcoal adsorbers with an efficiency of 99.9% for iodine make safe the use of up to 250 mc of I^{131} in the hood.

It is the purpose of these calculations to determine the amount of radioiodine which can be released to the hood exhaust in Rooms R-235 and E-263 in Bldg. 4500S without exceeding permissible exposures of personnel and without expending more than an appropriate share of the total activity which ORNL can safely discharge to the atmosphere.

Permissible Exposure Specifications

The basic requirement is that the 13-week total body dose received by a person must not exceed 3 rems or its equivalent. ORNL management may expend this permissible exposure at its discretion. This expendable resource must be allocated in such a way as to permit the various ORNL activities to be carried out without those interruptions which might be necessary to limit personnel exposure if such exposures were not regulated. For the purposes of this calculation, the following management decisions are assumed:

1. One-tenth of the permissible exposure of personnel may be received through general atmospheric contamination of ORNL origin. The other nine-tenths is reserved for individual exposures to external radiation or localized contamination. There is precedent for this assumption (1).
2. One-tenth of one week's permissible general atmospheric exposure may be received as a result of a single accident whose expected frequency is kept very small compared to 1 per week. No precedent for the factor of one-tenth is offered. It is based on the idea that perhaps ten accidental controlled releases per week may occur in an installation the size of ORNL. There is authority for permitting exposure at higher rates than the average permissible rate for shorter times provided integrated 13-week exposures do not exceed permissible levels (2).

3. Six-tenths of one week's permissible exposure may be received by an individual as a result of a single accidental release when no special control can be exercised over separate exposure of the individual. There is authority for this requirement for external radiation (3) and it is applied here for internal exposure.

Two kinds of exposure resulting from releases to the hood exhaust are recognized:

1. Persons breathing the atmosphere contaminated by the hood exhaust.
2. Persons on the roof breathing the undiluted hood exhaust.

For the first kind of exposure, an accidental release must not produce more than 0.1 x 0.1 x MPCa x 40 = 0.40 x MPCa (μc hr/cc) of integrated exposure, where MPCa is the maximum permissible concentration in air for 40 hours per week, 50 weeks per year, 50 years per lifetime as given in reference (4), and the two 0.1 factors come from the assumed management decisions (1) and (2) discussed above.

For the second kind of exposure an accidental release must not produce more than 0.6 x 40 x MPCa = 24 x MPCa (μc hr/cc) of integrated exposure. The difference of a factor of 60 for the two kinds of exposure results from a recognition of the different numbers of persons exposed and the different probabilities of their exposure.

Dilution Conditions

For the first kind of exposure (through general atmospheric contamination) the stack dilution factor for release at roof top level (50 feet above the ground) under unfavorable meteorological conditions (nighttime, inversion, 5 mph wind) is 2.1×10^{-4} sec/M^3. This figure may be obtained from meteorological dilution calculations as follows (5):

$$X_{max} = \frac{2Q}{\pi h^2 eu} \quad \frac{\sigma_z}{\sigma_y}$$

where

X_{max} = maximum ground concentration (c/M^3)

Q = source strength (c/sec)

u = mean wind speed (M/sec)

h = stack height (M)

σ_y = horizontal dispersion coefficient (M)

σ_z = vertical dispersion coefficient (M)

e = exponential base = 2.718

Values of σ_y and σ_z may be obtained from tables in reference (6).

The stack dilution factor is

$$\frac{X_{max}}{Q} = 2.1 \times 10^{-4} \frac{sec}{M^3} = \frac{2.1 \times 10^{-4}}{3600 \times 10^6} = 5.8 \times 10^{-14} \text{ hr/cc}$$

If an accidental release is to produce no more than 0.40 MPCa μc hr/cc integrated exposure, then no more than

$$\frac{0.40 \times MPCa}{5.8 \times 10^{-14}} = 6.9 \times 10^{12} \times MPCa(\mu c)$$

can be released. MPCa for I^{131} is 9×10^{-9} (μc/cc) so the maximum permissible release through the hood exhaust is $6.9 \times 10^{12} \times 9 \times 10^{-9} = 62{,}000$ μc as far as general atmospheric contamination is concerned.

For the second kind of exposure (breathing undiluted hood exhaust) the maximum permissible release to produce no more than 24 MPCa μc hr/cc for a hood volume flow rate of 700 cfm is:

$24 \text{ MPCa} \times 700 \times 28{,}317 \times 60 = 2.85 \times 10^{10} \times \text{MPCa } \mu c$

and the permissible release is 257 μc.

The more restrictive of these two limitations is the latter one placing a limit of 257 μc released through the hood exhaust.

Permissible Releases for Various Iodine Adsorber Arrangements

The following table lists the efficiencies which may be expected for several adsorbers, and the corresponding amounts of I^{131} which may be released into the hood without exceeding the 257 μc limit adopted above.

Adsorber Material	I Removal Efficiency(7)	Permissible I^{131} Release
No adsorber	0.0%	0.257 mc
Ag-Cu mesh, 1 in. thick	90%	2.57 mc
Activated charcoal, 1 in. thick	99.9%	257.0 mc

References

1. J. A. Cox, Operations Division Quarterly Report, October-December, 1958, ORNL-CF-58-12-147.

2. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, NBS Handbook 69, p. 8, paragraph b (1959); and ORNL Radiation Safety and Control Manual, p. 4-6 (June 1, 1961).

3. ORNL Radiation Safety and Control Manual, p. 4-4, second paragraph (June 1, 1961).

4. Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, NBS Handbook 69, Table 1, pages 24 ff. (1959). See also abridged table, ORNL Radiation Safety and Control Manual, Appendix B (June 1, 1961).

5. Gifford, Nuclear Safety, Vol. 2, No. 2, page 56 ff (December 1960), Equation 9, p. 58.

6. Gifford, Nuclear Safety, Vol. 2, No. 4, p. 47 ff., Figs. V-1 and V-2 (June 1961).

7. R. E. Adams and W. E. Browning, Jr., "Removal of Radioiodine from Air Streams by Activated Charcoal", ORNL-2872, March 17, 1960.